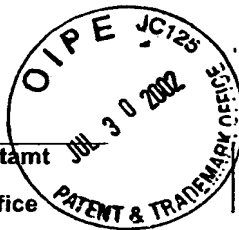




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(71) Applicant : **FUJITSU LIMITED  
1015, Kamikodanaka Nakahara-ku  
Kawasaki-shi Kanagawa 211 (JP)**

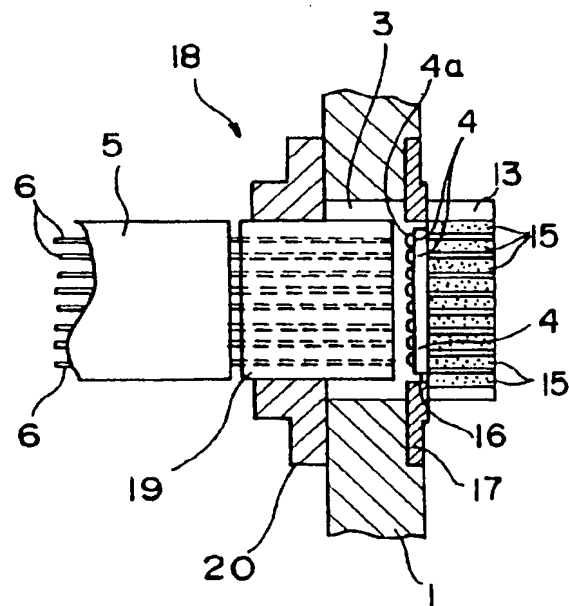
(72) Inventor : **Makiuchi, Masao, c/o Fujitsu Limited  
1015, Kamikodanaka, Nakahara-ku  
Kawasaki-shi, Kanagawa 211 (JP)**  
Inventor : **Nakagawa, Gohji, c/o Fujitsu Limited  
1015, Kamikodanaka, Nakahara-ku  
Kawasaki-shi, Kanagawa 211 (JP)**

(74) Representative : **Fane, Christopher Robin King  
et al  
HASELTINE LAKE & CO. Hazlitt House 28  
Southampton Buildings Chancery Lane  
London, WC2A 1AT (GB)**

(54) **Optical fibre coupling modules.**

(57) A package used to couple an optical fiber (6) and an optical device (4) to each other comprises a frame member (1) open at the top and the bottom thereof for accommodating an electronic part therein, the frame member (1) having an opening (3) formed in a portion of a side wall thereof in or adjacent which an optical fiber (6) and an optical device (4) are coupled to each other, a heat sink for closing one of the opening ends of the frame member (1), and a lid for closing the other opening end of the frame member (1).

*FIG. 6 (b)*



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This invention relates to optical fibre modules, for example a package for coupling an optical fiber and an optical device and an optical fiber-optical device module, and a package for coupling an optical fiber and a light emitting element or an optical fiber and a photodetector and an optical fiber-optical device module accommodated in and integrated with such package.

A module including an optical fiber and an optical device can serve to convert an electric signal in transmission into an optical signal or an optical signal into an electric signal.

Modules of the type mentioned allow transmission of parallel signals between different electronic system or between different circuit boards in an electronic system, to achieve good characteristics in the electronic system in terms of noise, crosstalk or transmission rate.

Where signals are transmitted between a plurality of electronic computers or signals are transmitted between different circuit boards in an electronic computer, the rate of signal processing in such electronic computer or computers can be raised by converting an optical signal into an electric signal and converting an electric signal into an optical signal.

In order to couple an optical fiber and an optical device to each other, it is required to develop a package of a small size with which such coupling can be performed readily. In this instance, a package for an opto-electronic coupling module is used to couple an optical fiber and optical devices such as a semiconductor laser or a light emitting diode or to couple an optical fiber and a light detecting element such as a PIN-photodiode. It is to be noted that a light emitting element, a photodetector, an optical waveguide modulator and other like elements are generally referred to each as optical device herein.

A package having such a structure as shown, for example, in FIGS. 1(a) and 1(b) has been proposed as a package of the type described above. The package is described in [1] T. Kato et al., IEEE Proc.42nd Electronic Components and Technology Conference pp.853-860, 1992.

Referring to FIGS. 1(a) and 1(b), a photodiode 101 serving as a light detecting element is placed on the bottom of a package body 100 which is open at the top thereof, and an optical fiber 102 extends through a side wall of the package body 100 and have the extreme end of the optical fiber 102 faces to a light receiving portion of the photodiode 101. The package body 100 is closed at the top thereof with a lid 103. The photodiode 101 and the optical fiber 102 are fixed in an opposing relationship to each other on a support table 104. Upon positioning, one of the photodiode 101 and the optical fiber 102 is fixed, and in this condition, the other is positioned relative to the one using a jig.

With the package of the structure described

above, in addition to a space required to mount the photodiode 101 and the optical fiber 102, spaces S for accepting such jig must be assured, which makes an obstacle to minimization of the package.

Besides, since the photodiode 101 and the optical fiber 102 are supported only from the bottom of the package, in such a condition that a plurality of such combinations are arranged in parallel to each other as shown FIG. 1(a), then torsion is likely caused between the photodiodes 101 and the optical fibers 102 by deformation of the bottom of the package or the support table 104 arising from thermal expansion so that optical axes of the photodiodes 101 and the optical fibers 102 are put out of alignment with each other. Such disalignment is remarkable where a multichannel optical device and multichannel optical fiber are coupled to each other.

It has been proposed in the following documents to attach an optical device to an end of an optical fiber array in order to prevent such disalignment as described above. However, neither of the documents discloses a structure of a package for accommodating them in an airtight condition.

[2] U.S. Patent No. 4,730,198 and

[3] Yusuke Ota, Robert G. Swartz, IEEE The Magazine of Lightwave Telecommunication Systems, Vol.2, No.2, pp.24-32, May 1991

Another structure has been proposed and is shown in FIG. 2 wherein optical fibers 107 and optical devices 108 are coupled to each other and an electronic part 106 such as an LSI is accommodated in a package 105. The package 105 has a bottomed structure with the top opened, and a space which is required to mount the optical fibers 107 and the optical devices 108 is assured around the electronic part 106 and the optical devices 108. The module of the type just described is disclosed, for example, in [4] Japanese Patent Laid-Open Application No. Sho. 63-18308.

It is desirable to provide an optical fiber-optical device coupling package and an optical fiber-optical device module wherein the space required to couple an optical fiber and an optical device to each other is small and disalignment of the optical fiber and the optical device caused by thermal expansion is minimized.

An embodiment of the present invention can provide an optical fiber-optical device coupling package and an optical fiber-optical device module, comprising a frame open at the top and the bottom thereof for accommodating an electronic part therein, said frame having an opening formed in a portion of a side wall thereof in or adjacent which an optical fiber and an optical device are coupled to each other, and first and second lids for closing the top and the bottom of said frame, respectively. The first or second lid may be formed as a heat sink.

In the package, a space of an electronic part ac-

commodating chamber in the electronic member is applied as a space for accepting therein a jig which is used to couple the optical fiber and the optical device to each other, and besides the space is open at the top and the bottom thereof. Consequently, the jig for mounting an optical device can be inserted into the space both from above and from below, and accordingly, the operability in such coupling is enhanced. Further, if the coupled end of the optical fiber is supported by means of a connector or a ferrule, mounting of the optical fiber can be performed from outside the frame, and consequently, the operation is facilitated.

Further, since the space required to couple the optical fiber and the optical device to each other may be only the opening in the side wall, the space necessary for optical coupling is reduced remarkably. If the optical device is attached to an end face of a ferrule for an optical fiber to couple the optical fiber and the optical device to each other and then inserted into the opening in the side wall of the frame, then the operation for coupling between the optical device and the optical fiber is further reduced, and besides, the members are enclosed in an airtight condition in the package.

Further, since the optical fiber and the optical device are secured to the side wall of the frame, even if the electronic part in the frame operates so that the frame is deformed by thermal expansion of the same, the deformation of the side wall around the opening is very little comparing with the deformation of the entire frame and does not have such an influence as to cause disalignment of the optical axes of the optical fiber and the optical device. Further, even if the thickness of the frame is increased by thermal expansion of the same so that the distance between the extreme end of the optical fiber and the optical device is increased, such increase does not make an obstacle to transmission of an optical signal.

Where the frame is closed at the top or the bottom thereof with the heat sink (or lid) and the electronic part and the heat sink are disposed in contact with each other, the electronic part is cooled by the heat sink so that the thermal expansion of the frame is restricted. If a material having a low thermal conductivity is interposed between the frame and the heat sink, the thermal expansion of the frame is further reduced, and heat produced at the coupling portions of the optical device and the optical fiber is cooled by way of the frame, not by the heat sink.

Where a partition is provided in the inside of the frame so that a plurality of electronic parts may be accommodated in the frame, the electronic parts can be electrically isolated readily from each other.

Where a lead for connection of a terminal of the electronic part is formed along an inner wall of the frame in such a manner as to extend to the outside of the frame in order to electrically lead out the terminal of the electronic part to the outside, there is no neces-

sity of providing a space into which a jig is to be accepted to establish electric connection of the electronic part, and consequently, the optical fiber-optical device coupling package and the optical fiber-optical device module can be formed in a very small size. Where an electrode lead connected to the optical device has a microstrip line structure, otherwise possible crosstalk between different optical device channels is eliminated. Further, since use of bonding wires is restricted to the minimum and patterned wiring lines are used, also skew is minimized.

Reference will now be made, by way of example, to the accompanying drawings, in which:

FIGS. 1(a) and 1(b) are a plan view and a side elevational sectional view, respectively, showing a first example of conventional optical fiber-optical device module;

FIG. 2 is a plan view showing a second example of conventional optical fiber-optical device module in which an electronic part is accommodated; FIG. 3 is an exploded perspective view of an optical fiber-optical device module of a first embodiment of the present invention as viewed from the side of a heat sink;

FIG. 4 is an exploded perspective view of the optical fiber-optical device module of FIG. 3 as viewed from the side of a rear lid;

FIG. 5(a) is a plan view showing the optical fiber-optical device module of FIG. 3 with the lid removed, and FIG. 5(b) is a side elevational view of the optical fiber-optical device module;

FIG. 6(a) is a perspective view showing an optical device employed in the optical fiber-optical device module of FIG. 3, and FIG. 6(b) is a plan view illustrating a coupled condition between an optical fiber and an optical device in the optical fiber-optical device module of FIG. 3;

FIG. 7(a) is a plan view illustrating a coupled condition between an optical fiber and an optical device according to a second embodiment of the present invention, and FIG. 7(b) is a side elevational view illustrating the coupled condition;

FIG. 8(a) is a plan view illustrating a coupled condition between an optical fiber and an optical device according to a third embodiment of the present invention, and FIG. 8(b) is a side elevational view illustrating the coupled condition;

FIG. 9(a) is a perspective view showing an optical fiber and optical device package of a fourth embodiment of the present invention, and FIG. 9(b) is a side elevational view of the optical fiber and optical device package;

FIG. 10 is a side elevational view showing a package of another form of the fourth embodiment of the present invention;

FIG. 11 is a sectional view showing an optical fiber-optical device module of a fifth embodiment of the present invention in a disassembled condi-

tion;

FIG. 12 is a sectional view showing an optical fiber-optical device module of a sixth embodiment of the present invention in a disassembled condition;

FIG. 13(a) is a sectional view showing an optical fiber-optical device module of a seventh embodiment of the present invention in a disassembled condition, and FIG. 13(b) is a plan view showing the module with a heat sink of a package removed;

FIG. 14 is a sectional view showing an optical fiber-optical device module of an eighth embodiment of the present invention in a disassembled condition;

FIG. 15 is a sectional view showing another form of the optical fiber-optical device module of the sixth embodiment of the present invention;

FIG. 16(a) is a perspective view showing construction of an optical fiber and an optical device of the optical fiber-optical device module of FIG. 14, and FIG. 16(b) is a perspective view illustrating a connection condition between the optical device and the optical fiber; and

FIG. 17 is a perspective view illustrating a connection condition between an optical device and an optical fiber of another construction of the eighth embodiment of the present invention.

A first embodiment of the present invention will be described with reference to FIGS. 3, 4, 5(a) and 5(b), and 6(a) and 6(b).

An optical fiber-optical device module of the present embodiment includes an electronic part 9 accommodated in a package formed from a frame 1, a heat sink 8 and a rear lid 10, and a plurality of optical fibers 6 and a plurality of photodetectors 4 are paired with and coupled to each other and accommodated in each of a pair of openings 3 formed in the frame 2.

The frame 1 is open at the top and the bottom thereof, and the inside of the frame 1 serves as an electronic part accommodating chamber 2. The thickness of side walls of the frame 1 ranges from 1.5 to 2.5 mm or so, and the openings 3 each having four escape holes 3a at the four corners thereof are formed to extend perpendicularly through one of the side walls of the frame 1. At a portion of each of the openings 3 adjacent the electronic part accommodating chamber 2, such photodetectors 4 as shown in FIG. 6(a) are mounted adjacent a support base plate 13, and at the opposite portion of each of the openings 3, such optical fibers 6 covered with a multi-channel ribbon 5 of vinyl as shown in FIG. 6(b) are provided at the pitch of, for example, 250  $\mu$ m. Light receiving faces of the photodetectors 4 and extreme ends of the optical fibers 6 are disposed in an opposing relationship in the openings 3.

A heat sink 8 is fitted at one of the top and bottom openings of the frame 1 and has a plurality of fins 7

formed on an outer face thereof as shown in FIG. 3. The electronic part 9 is mounted on the opposite face of the heat sink 8 adjacent the frame 1 such that it is accommodated in the electronic part accommodating chamber 2 when the heat sink 8 is mounted in position on the frame 1. The electronic part 9 may be, for example, a semiconductor integrated circuit device (LSI). The other opening of the frame 1 remote from the heat sink 8 is closed with the rear lid 10.

A plurality of electrode leads 11 are held in each of support plates 12 made of a ceramic material such as alumina and are arranged in parallel to each other. The support plates 12 are mounted on and extend through the other side walls of the frame 1 than the side wall in which the openings 3 are formed. Each of the electrode leads 11 is bent substantially like a step and extends, at an end portion thereof, outwardly from a lower face of the frame 1 adjacent the rear lid 10. The other ends of the electrode leads 11 are exposed from above the support plates 12 extending inwardly of the electronic part accommodating chamber 2, and the thus exposed portions are connected to conductive pads 9a of the electronic part 9, for example, by wire bonding.

Referring to FIG. 6(a), the photodetectors 4 in a array chip are arranged in parallel to each other at the distance of, for example, 250  $\mu$ m and formed as a unitary member. A microlens 4a is integrated on the light receiving face of each of the photodetectors 4, and the photodetectors 4 are mounted on a support base plate 13.

A wiring pattern 14 for connecting the photodetectors 4 by flip chip bonding is formed on an upper face of the support base plate 13. The wiring pattern 14 is connected to electrode leads 15 embedded in recessed portions at a face portion of the support base plate 13.

The support base plate 13 is secured to a support frame 17, which is constituted from a plate having a recessed window formed by cutting the same adjacent the electrode leads 15 and exposing the microlenses 4a of the photodetectors 4 therethrough.

The support frame 17 is secured to the frame 1 such that the light receiving faces of the photodetectors 4 are directed toward the inside of the opening 3 of the frame 1 and the electrode leads 15 of the support base plate 13 are opposed to the rear lid 10. The support frame 17 is secured to the frame 1 by means of a YAG laser or a bonding agent in accordance with a material of the frame 1, and the electrode leads 15 of the support base plate 13 are connected by wire bonding or like means to the pads 9a of the electronic part 9 disposed in such a manner as shown in FIG. 5(a).

The optical fibers 6 are mounted such that, as shown in FIG. 6(b), end portions thereof exposed from the ribbon 5 are attached to a connector 18 with the extreme ends thereof directed toward the micro-

lenses 4a of the photodetectors 4. The connector 18 has a structure wherein a block 19 in which the optical fibers 6 are held is supported on a cap 20, and in order to secure the connector 18 to the frame 1, a YAG laser, a bonding agent or some other means is used in accordance with a material of the frame 1.

It is to be noted that, if the photodetectors 4, the optical fibers 6 and the electronic part 9 are mounted into and bonded to the frame 1 by wire bonding and then the heat sink 7 is fitted into the frame 1 using metal welding, a bonding agent, a rubber packing or some other suitable means, whereafter the rear lid 10 is fixed to the bottom of the frame 1 by, for example, seam welding so as to establish an airtight condition, then an optical transmission coupling apparatus is completed.

It is to be noted that the frame 1, the support frame 17 for optical devices and so forth may be made of such suitable materials as a ceramic material, a metal or the like taking the materials of the optical devices, the connector 18 for optical fibers and so forth, the securing method of them and so forth into consideration.

With the package of the structure described above, since the optical fibers 6 and the photodetectors 4 are coupled to each other in each of the openings 3 in the side wall of the frame 1, the space necessary for connection between them is a projected portion of the support base plate 13 on which the photodetectors 4 are mounted, and consequently, the space necessary for optical coupling is reduced remarkably.

Besides, the space for accepting a jig which is used upon mounting of the photodetectors 4 may be the space of the electronic part accommodating chamber 2 in the frame 1. Moreover, since the frame 1 is open at the bottom thereof, a jig for mounting a photodetector can be inserted from above or below, and consequently, the operability is enhanced. Meanwhile, since the optical fibers 6 can be mounted from the outside of the frame 1, the operation is facilitated.

Positioning for connection between the photodetectors 4 and the optical fibers 6 is performed while light is irradiated from the optical fibers 6 and received by the photodetectors 4.

Further, since the optical fibers 6 and the optical devices 4 are secured to the end portion of the frame 1, even if the electronic part in the frame 1 operates so that the frame 1 is deformed by thermal expansion, the deformation of the side wall around the openings 3 is so small comparing with the deformation of the entire frame 1 that it will have no such influence as to cause disalignment of optical axis of the optical fibers 6 and the photodetectors 4. Further, even if the thickness of the frames 1 is increased a little by thermal expansion of it to expand the distances between the extreme ends of the optical fibers 6 and the optical devices 4, the amount of such expansion

is so small that it does not make an obstacle to transmission of an optical signal. Further, heat produced at such optical coupling portions is radiated from the frame 1, and consequently, the cooling efficiency is high.

Besides, since the optical fibers 6 and the photodetectors 4 are supported in the openings 3 of the frame 1, the mechanical strength is high. Further, if conductive films are formed on the rear faces of the electrode leads 11 and 15 described above, a microstrip line structure is established, and consequently, crosstalk or skew is not caused readily between different optical device channels.

It is to be noted that, while photodetectors are used in the embodiment described above, light emitting elements such as semiconductor lasers or light emitting diodes may be adapted instead, or semiconductor optical modulation elements or some other optical devices may be employed. Where light emitting elements are used, they are first inserted, for example, by a small amount into an opening 3 and secured to the side wall of the frame 1, and then optical fibers are adjusted in position while the light emitting elements are energized.

Further, while the heat sink 8 in the embodiment described above contacts directly with the frame 1, if such a heat insulating member 1a as shown in FIG. 3 is held between the heat sink 8 and the frame 1, then heat of the electronic part 9 is radiated from the heat sink 8 while heat of the coupling portions between the optical fibers 6 and the optical devices 4 is radiated from the frame 1 separately from the heat sink 8, and consequently, the thermal expansion of the optical coupling portions in the openings 3 can be restricted low.

While, in the embodiment described above, the light receiving sides of the optical devices are inserted by a small amount in the openings 3 as seen in FIG. 6(b), the support base plates 13 for optical devices may be formed longer in the direction of the optical axes so that the optical devices 4 may be inserted in the openings 3 as seen in FIGS. 7(a) and 7(b).

In this instance, the faces on which the photodetectors 4 are mounted may be inclined obliquely a little as shown in FIG. 7(b), and even with such structure, no trouble occurs if the extreme ends of the photodetectors 4 are located in the proximity of the microlenses 4a.

While, in the embodiments described above, the extreme ends of the optical fibers 6 are cut perpendicularly so that the photodetectors 4 may be disposed in an opposing relationship to the extreme ends of the optical fibers 6 in the openings 3, the extreme ends of the optical fibers 6 may otherwise be cut obliquely as shown in FIGS. 8(a) and 8(b).

In this instance, the photodetectors 4 are placed on and connected to the electrode leads 15 of the support base plate 13 such that the light receiving

faces 4a thereof may be directed in a perpendicular direction to the direction in which the openings 3 extend through the side wall of the frame 1. The electrode leads 15 are disposed at such positions that they face the rear lid 10 shown in FIGS. 3 and 4. Meanwhile, the support frame 17 for securing the support base plate 13 to the frame 1 is secured to face portions of the electrode leads 15 and the support base plate 13 on the rear side of the electrode leads 15.

The cut faces of the optical fibers 6 may be used as reflecting mirrors so that reflected light from them may be irradiated upon the photodetectors 4.

While, in the embodiments described above, the plurality of leads 11 are held in the support plates 12 and extend through the side wall of the frame 1, they may otherwise be disposed in such a manner as shown in FIGS. 9(a) and 9(b) that lead support layers 21 and 22 are placed below the frame 1 while the leads 11 bent in a step-like configuration extend inwardly and outwardly from between the lead support layers 21 and 22. In this instance, the lead support layer 21 disposed adjacent the rear lid 10 do not extend into the inside of the frame 1, and end portions of the leads 11 on the other lead support layer 22 are exposed to the rear lid 10 side.

Or, such a structure as shown in FIG. 10 may be employed wherein the leads 11 are bent in the inside of the frame 1 and extend through the rear lid 10 while outer end portions thereof extend outwardly from the rear lid 10.

While, in the embodiments described above, the electronic part 9 is mounted on the heat sink 8, alternatively, as shown in FIG. 11, a plurality of electronic parts 23 and 24 may be bonded by flip-chip bonding to a wiring pattern (not shown) formed on a face of a rear lid 22 adjacent the frame 1.

In this instance, lead pins 25 extend from a lower face of the rear lid 22 to allow electric connection to an external apparatus. Further, pads 26 and 27 of a high conductivity for transmitting heat from the electronic parts 23 and 24 are provided on the face of the heat sink 8 adjacent the frame 1 and are held in contact with the electronic parts 23 and 24 to cool them.

While, in the first embodiment described above, the bonding pads 9a of the electronic part 9 mounted on the heat sink 8 and the inner ends of the leads 11 are connected to each other by wire bonding, some other connection structure may alternatively be employed.

For example, as shown in FIG. 12, a wiring pattern 29 is formed on a face of a rear lid 28 adjacent the frame 1, and an electronic part 30 is connected to the wiring pattern 29 by flip-chip bonding while exposed faces at the inner ends of the leads 11 are disposed adjacent the rear lid 10. The wiring pattern 29 and the leads 11 are held in contact with each other directly or by way of a pad 31. This eliminates the time

required for wire bonding.

Where the electronic part 30 has a large size, the pads 9a of the electronic part 9 and the inner ends of the leads 11 may be held in an opposing relationship to and in direct contact with each other. This structure allows, when some trouble occurs, the heat sink 8 or the lid 10 to be opened to perform repair or exchange the electronic part 30.

While, in the first embodiment described above, the electronic part accommodating chamber 2 is provided only by one, the inside of the frame may be partitioned to form two such electronic part accommodating chambers as shown in FIGS. 13(a) and 13(b).

In particular, a conductive frame 32, which is open at the top and the bottom thereof, is partitioned by a partition 35 to define a pair of electronic part accommodating chambers 33 and 34, and an insulating support layer 37 having leads 36 held therein is formed in a portion of each of the electronic part accommodating chambers 33 and 34. Another insulating support layer 37 made of a ceramic material and holding leads 38 therein extends through the partition 35 so that electronic parts 46 and 47 accommodated in the electronic part accommodating chambers 33 and 34, respectively, may be electrically connected to each other.

A pair of projecting portions 40 and 41 are formed on a face of a heat sink 39 adjacent the frame 32 and are fitted in the electronic part accommodating chambers 33 and 34, respectively, and electronic part carrying circuit boards 44 and 45 on which wiring patterns 42 and 43 are formed are adhered to the projecting portions 40 and 41 of the heat sink 39, respectively. Electronic parts 46 and 47 such as LSIs are mounted on the electronic part carrying circuit boards 44 and 45 and terminals of them are connected to the wiring patterns 42 and 43 by wire bonding, respectively. When the heat sink 39 on which the electronic parts 46 and 47 are mounted are mounted at the top of the frame 32, the wiring patterns 42 and 43 of the electronic part carrying circuit boards 44 and 45 contact with the leads 36 and 37, respectively, and the wiring pattern 42 contacts with a stripe pattern 15 of a support base plate 13 for optical devices mounted in an opening 48 in a side wall of the frame 32.

It is to be noted that a portion of the frame 32 remote from the heat sink 39 is closed with a rear lid 49.

With such structure as described above, since the frame 32 and the partition 35 are formed from a conductive material and the frame 32 is partitioned by the partition 35 to define the two electronic part accommodating chambers 33 and 34, when an LSI for microwaves is accommodated as an electronic part in the frame 1, the LSI is held in a shielded condition, and accordingly, it will not have a bad signaling influence upon any other electronic part.

While, in the seventh embodiment described above, the two electronic part accommodating cham-

bers 33 and 34 are formed in the frame 32, where the optical devices to be coupled to optical fibers are, for example, photodiodes, one of LSIs 51 and 52 which is to be shielded may be covered with a conductive cap 50 as shown in FIG. 14.

By the way, a heat sink 53 shown in FIG. 14 has an increased thermal diffusion effect by increasing the number of fins 54 in a region thereof corresponding to the LSI 52 which generates a great amount of heat or by forming the grooves between the fins 54 deeply. The heat sink 53 can thus make the temperature distribution of the optical transmission coupling apparatus uniform thereby to decrease otherwise possible deformation of the frame 55 arising from a non-uniform thermal expansion distribution.

In FIG. 14, reference number 56 denotes a lead attached in an isolated condition on a side portion of the frame 55, 57 a rear lid mounted below the frame 55, 58 an opening formed in a side wall of the frame, 59 a support base plate on which the photodetectors are mounted, and 60 an optical fiber.

By the way, where the optical devices mounted in the opening 58 are semiconductor lasers, it is little necessary to shield an LSI connected to them or to take a heat radiating effect into consideration, and accordingly, as shown in FIG. 15, the LSI 51 is not covered with a cap and besides the distribution of fins 61 of the heat sink 60 is uniform. In this instance, only it is necessary to replace the heat sink with another heat sink of the different structure.

While, in the embodiments described above, the optical devices are mounted into the openings, formed in the side wall of the frame of the package, from the electronic part accommodating chamber side while the optical fibers are mounted into the openings from the other or outer side, the optical fibers and the optical devices may otherwise be coupled to each other outside the frame as seen in FIGS. 16(a) and 16(b).

End portions of the optical fibers 6 coated with a metal are exposed from the multi-channel ribbon 5 and secured in an airtight condition in a block 19 made of silicon, and the block 19 is attached to a ferule 62 for the optical fibers 6. The block 19 is inserted in an airtight condition in a hole 63 of the ferule 62.

The optical fibers 6, the block 19 and the ferule 62 are disposed such that end faces of them may be aligned with each other in a plane.

A plurality of semiconductor lasers 64 are carried on an optical device carrier 65 and have optical output ends thereof disposed along an edge at an end of the optical device carrier 65. Electrodes of the semiconductor lasers 64 are connected directly or by way of wires to an electrode pattern 66 formed on an element carrying face of the optical device carrier 65.

The optical device carrier 65 is secured to a metal stem 67, which is positioned such that an edge at an end thereof is aligned with and extends along the opt-

ical output ends of the semiconductor lasers 64. A pair of arms 68 are formed adjacent side portions of the metal stem 67 on the opposite sides of the semiconductor layer 65 and extend in a perpendicular direction from the carrying face of the optical device carrier 65, and end faces of the arms 68 adjacent the optical output ends of the semiconductor lasers 65 are formed in an aligned condition with an end face of the metal stem 67.

The arms 68 are fixed to the end face of the ferule 62 at a moment by welding using a YAG laser while the optical output ends of the semiconductor lasers 64 and the end faces of the optical fibers 6 are opposed to each other.

Adjustment in position between the optical output ends of the semiconductor lasers 65 and the end faces of the optical fibers 6 is performed while light emitted from the semiconductor lasers 64 is irradiated upon the optical fibers 6, and is thus performed by movement of the metal stem 67 in the x direction and the y direction on the end face of the ferule 62 and by angular adjustment of the metal stem 67 with respect to the z axis perpendicular to the x and y directions.

When the ferule 62 for optical fibers is to be mounted onto the frame 1 shown in FIG. 3, such a procedure is adopted that a sleeve 62a of the ferule 62 is accommodated into an opening 3 of the frame 1 until a flange 62b of the ferule 62 is abutted with a side wall of the frame 1, and in this condition, the arms 68 of the metal stem 67 and the end face of the ferule 62 are fixed to each other by YAG laser welding. It is to be noted that optical devices to be carried on the optical device carrier 65 are not limited to semiconductor lasers but may be such photodetectors as in the first embodiment.

Where the optical fibers and the optical devices are coupled to each other outside the package in this manner, it is only required that, in the frame 1 of the package 1 shown in FIG. 4, the semiconductor lasers 64, the electronic parts 9 and the leads 11 be electrically connected to each other and then the heat sink 8 and the rear lid 10 be fitted to the top and the bottom of the frame 1, and accordingly, the yield in assembly is enhanced.

Also in the present embodiment, similarly as in the first embodiment, heat generated from the electronic part 9 mounted in the package is radiated from the heat sink 8 to the outside, and heat generated from the semiconductor lasers 64 is radiated sufficiently from the frame 1 by way of the ferule 62 for optical fibers.

By the way, while the ferule 62 for optical fibers shown in FIGS. 16(a) and 16(b) has such a structure that the hole 63 is formed in the ferule 62 and the block 19 is inserted in the hole 63, alternatively such a structure as shown in FIG. 17 may be employed wherein the sleeve 62c of the ferule 62 is formed sub-

stantially in a U-shaped section and the block is carried in the recessed portion of the sleeve 62c.

Further, the distance between the opposite side faces of the arms 68 of the metal stem 67 may be smaller than the width of the sleeve 62a of the ferule 62 as shown in FIG. 16(b) or alternatively be equal to the width of the sleeve 62c as shown in FIG. 17. Where the distance is smaller than the width of the sleeve 62a, welding for securing the metal stem 67 is performed on the end face of the ferule 6, but where the distance is equal to the width of the sleeve 62a, welding is performed on a side portion of the sleeve 62c.

### Claims

1. An optical fibre coupling module comprising a housing structure surrounding an internal region of the module and including a side wall portion formed with an opening, and further comprising an optical receiving or emitting device rigidly attached to the said side wall portion, so as to be in or adjacent to the said opening, and an optical fibre attached to the outside of the said wall portion so that a free end of the fibre is located close to and in operatively coupled relationship with the said receiving or emitting device.
2. An optical fiber-optical device coupling package, comprising:
  - a frame member (1) open at the top and the bottom thereof for accommodating an electronic part (9) therein;
  - said frame member (1) having an opening (3) formed in a portion of a side wall thereof in or adjacent which an optical fiber (6) and an optical device (4) are coupled to each other; and
  - first and second lids (8,10) for closing the top and the bottom of said frame member (1), respectively.
3. An optical fiber-optical device coupling package according to claim 2, wherein said first lid (8) has heat radiating fins (7) formed thereon.
4. An optical fiber-optical device coupling package according to claim 3, further comprising a heat insulating member (1a) interposed between said first lid (8) and said frame member (1).
5. An optical fiber-optical device coupling package according to claim 2, 3 or 4, further comprising lead terminals (11,11a) extending through said side wall of said frame member (1).
6. An optical fiber-optical device coupling package according to claim 5, wherein said frame member (1) is made of a conductive material, and said lead terminals (11,11a) are electrically isolated from said frame member (1).
7. An optical fiber-optical device coupling package according to claim 2, 3 or 4, further comprising lead terminals (11a) extending from said frame member (1) to the outside through said second lid (10).
8. An optical fiber-optical device module, comprising:
  - a frame member (1,32) open at the top and the bottom thereof for accommodating an electronic part (9) therein;
  - said frame member (1,32) having an opening (3) formed in a side wall thereof;
  - an optical device (4,64) disposed in said opening (3) on the inner side of said frame member (1,32);
  - an optical fiber (6) disposed in said opening (3) on the outer side of said frame member (1,32) and optically coupled to said optical device (4,64) in said opening (3); and
  - first and second lids (8,10,22,53) for closing the top and the bottom of said frame member (1,32), respectively.
9. An optical fiber-optical device module according to claim 8, including a plurality of such optical fibers (6) and a corresponding plurality of such optical devices (4).
10. An optical fiber-optical device module according to claim 8, further comprising a ferule (62) fitted in said opening (3) and having said optical fiber (6) mounted thereon, said optical device (64) being secured to an end face of said ferule (62) adjacent said opening (3).
11. An optical fiber-optical device module according to claim 8, 9 or 10, further comprising a lead (11) extending through said side wall of said frame member (1).
12. An optical fiber-optical device module according to claim 11, wherein said lead (11) is connected to an electrode (9a) of said electronic part (9) by way of a conductive member, and said electrode (9a) of said electronic part (9) is connected to an electrode (15) of said optical device (4) by way of another conductive member.
13. An optical fiber-optical device module according to claim 11, wherein said lead (11) contacts directly with an electrode (9a) of said electronic part (9) in said frame member (1).



14. An optical fiber-optical device module according to claim 8, wherein the electronic part (9) is carried on a face of said first lid (8) while heat radiating fins (7) are formed on the opposite face of said first lid (8).
15. An optical fiber-optical device module according to claim 8, wherein the electronic part (9) is carried on a face of said second lid (22) adjacent said frame member (1) and leads (25) is connected to the opposite face of said second lid (22), and a face of said first lid (8) adjacent said frame member (1) is thermally connected to said electronic part (9) and heat radiating fins (7) are formed on the opposite face of said first lid (8).
16. An optical fiber-optical device module according to claim 8, further comprising a support base plate (13) having said optical device (4) mounted thereon, said support base plate (13) having a wiring pattern (15) in the form of a microstrip line formed on a surface thereof.
17. An optical fiber-optical device module according to claim 8, wherein the electronic part (23,24) is disposed by a plural number in said frame member (1).
18. An optical fiber-optical device module according to claim 17, wherein at least one of the electronic parts (51,52) accommodated in said frame member (1) is covered with a conductive cap (50).
19. An optical fiber-optical device module according to claim 8, wherein the inside of said frame member (32) is partitioned into a plurality of spaces by a partition (35), and the electronic part (44,45) is accommodated in each of said spaces.
20. An optical fiber-optical device module according to claim 19, further comprising a lead (38) extending through said partition (35).
21. An optical fiber-optical device module according to claim 8, wherein said first lid (53) has a plurality of heat radiating fins (54) formed in a non-uniform distribution density thereon.
22. An optical fiber-optical device module according to claim 8, wherein said first lid (53) has a plurality of heat radiating fins (54) formed thereon and having non-uniform surface areas.
23. An optical fiber-optical device according to claim 8, wherein an end portion of said optical fiber (6) adjacent said opening (3) has a face inclined with respect to an optical axis of said optical fiber (6), and an optical input portion or an optical output

portion of said optical device (4) is disposed around said optical fiber (6) in the proximity of said inclined face of said optical fiber (6).

24. An optical fiber-optical device module according to claim 8, wherein an end of said optical fiber (6) is attached to a connector (18) fitted in said opening (3).

FIG. 1 (a)  
(Prior Art)

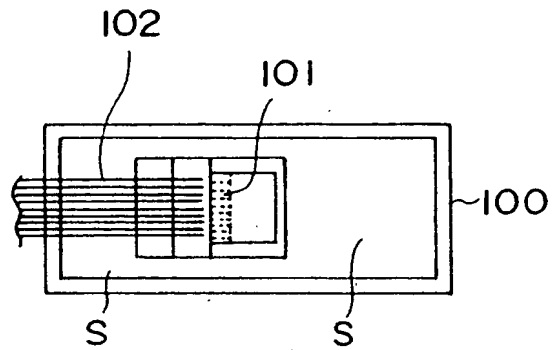


FIG. 1 (b)  
(Prior Art)

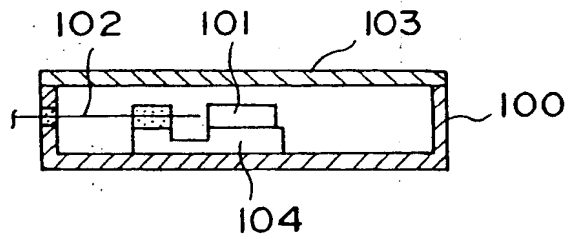


FIG. 2  
(Prior Art)

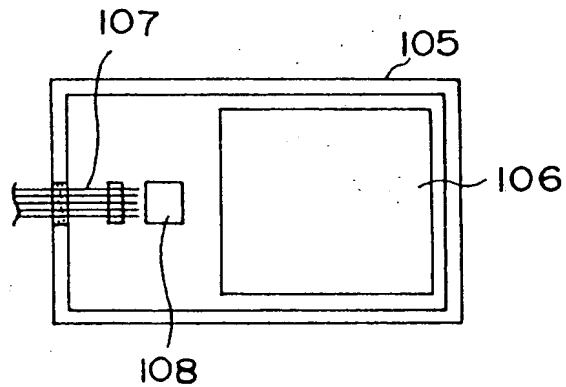


FIG. 3

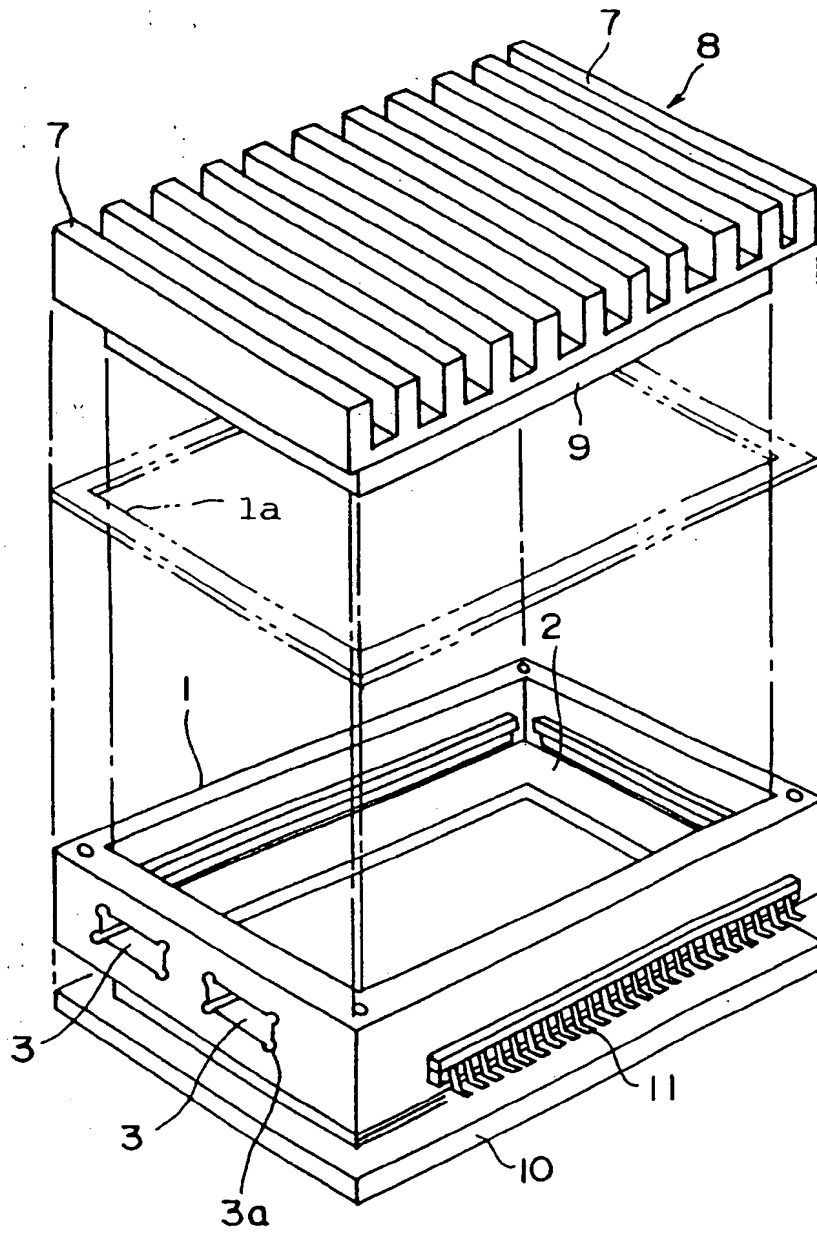


FIG. 4

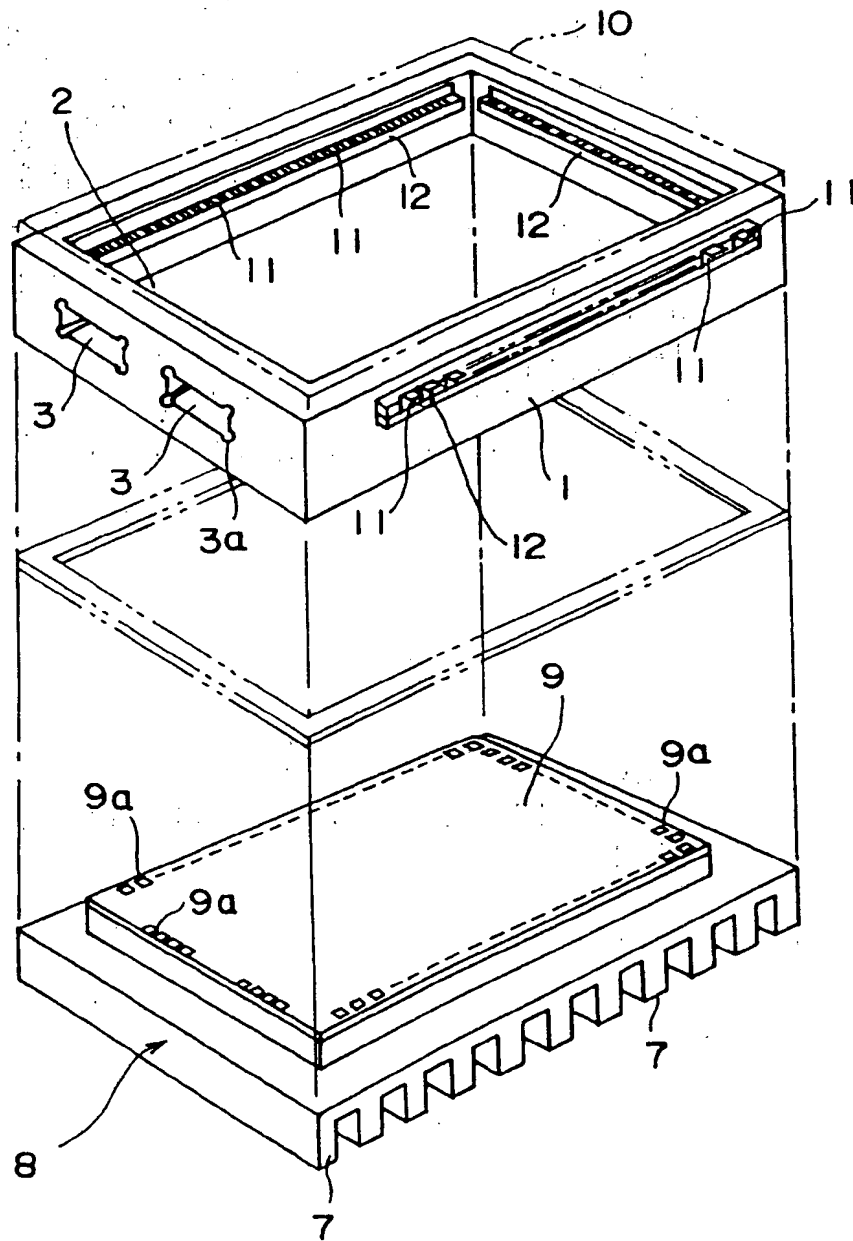


FIG. 5 (a)

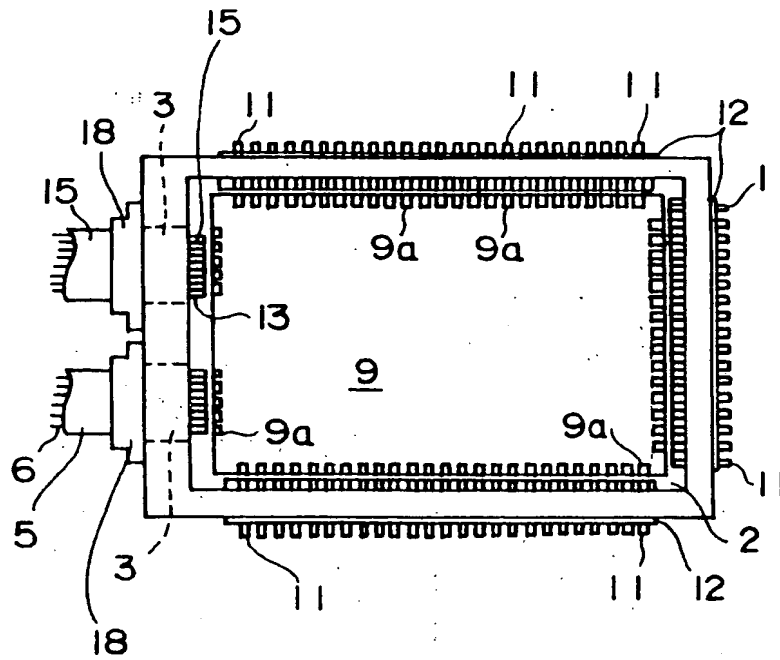


FIG. 5 (b)

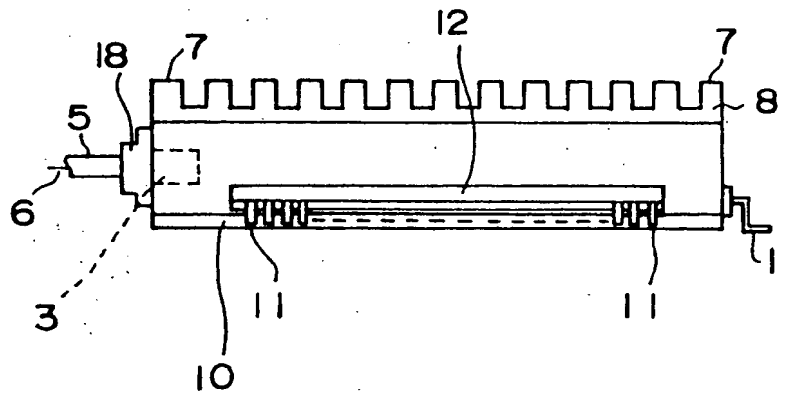


FIG. 6 (a)

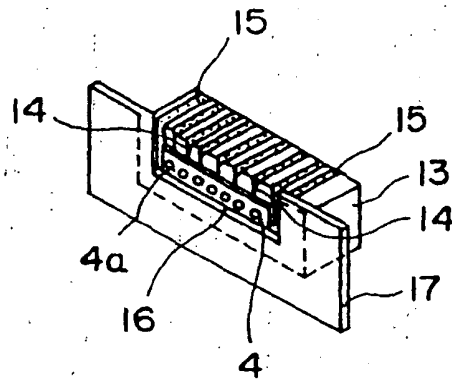


FIG. 6 (b)

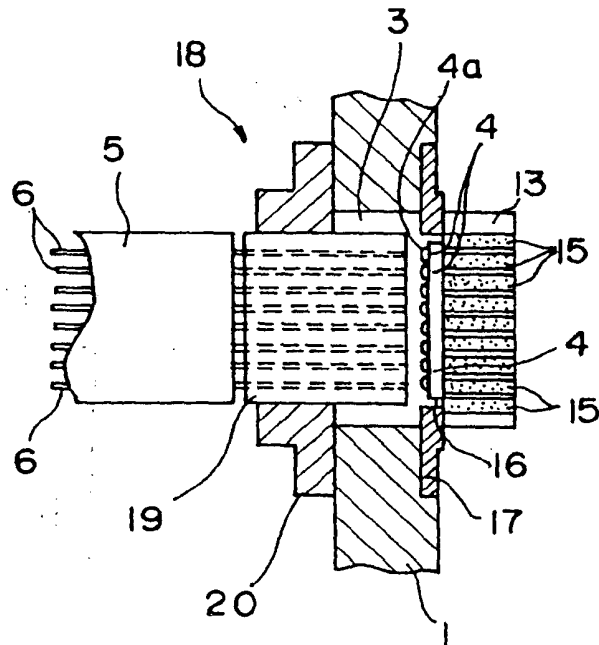


FIG. 7 (a)

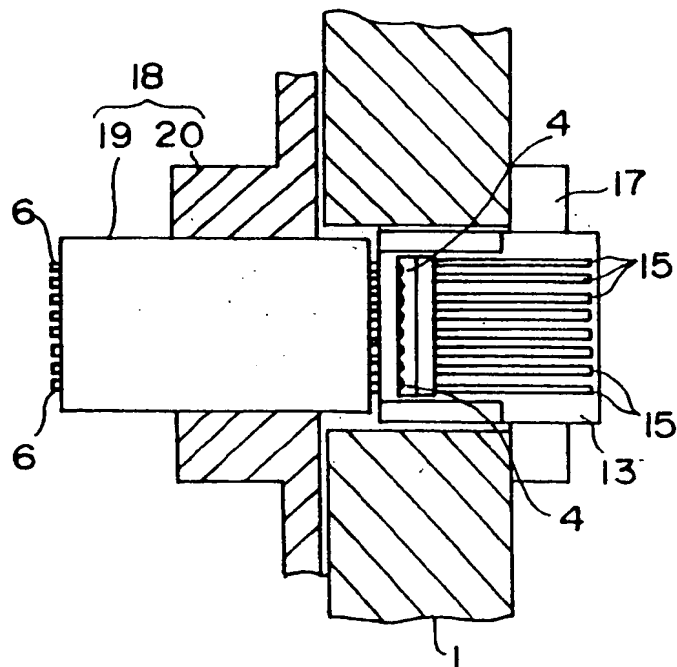


FIG. 7 (b)

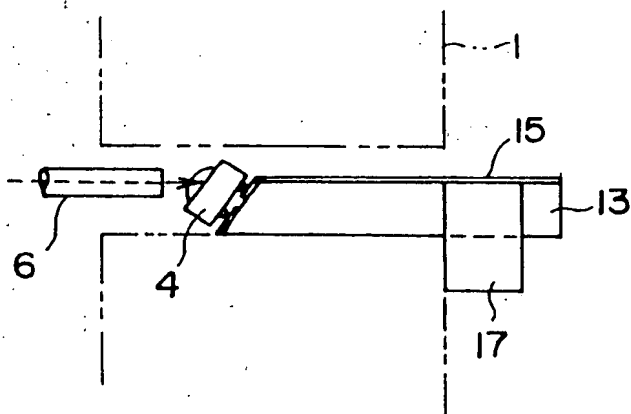


FIG. 8 (a)

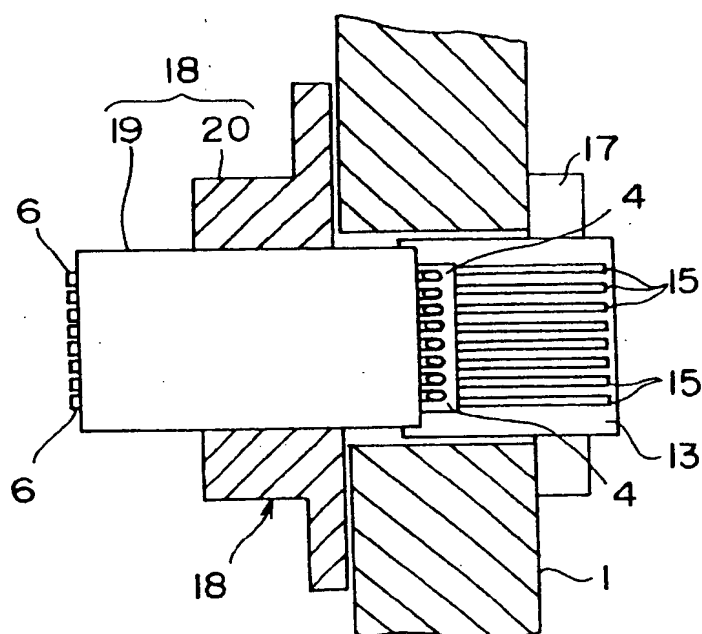


FIG. 8 (b)

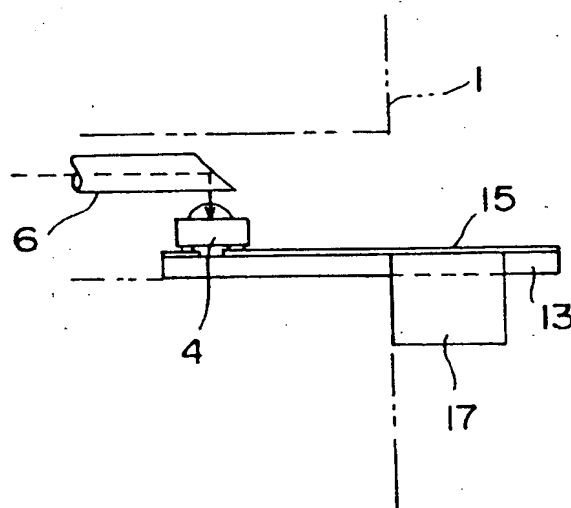




FIG. 9 (a)

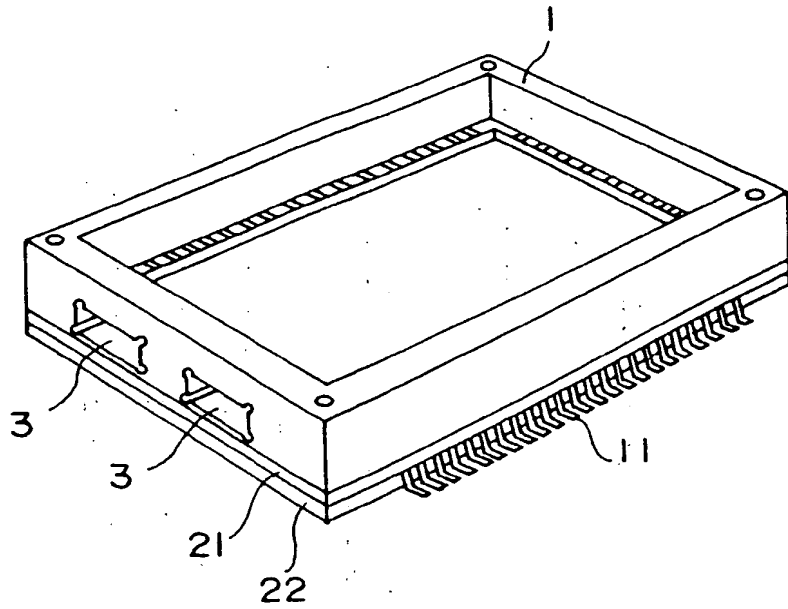


FIG. 9 (b)

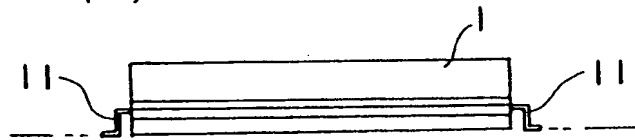


FIG. 10

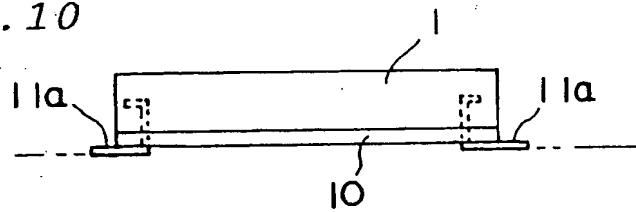


FIG. 11

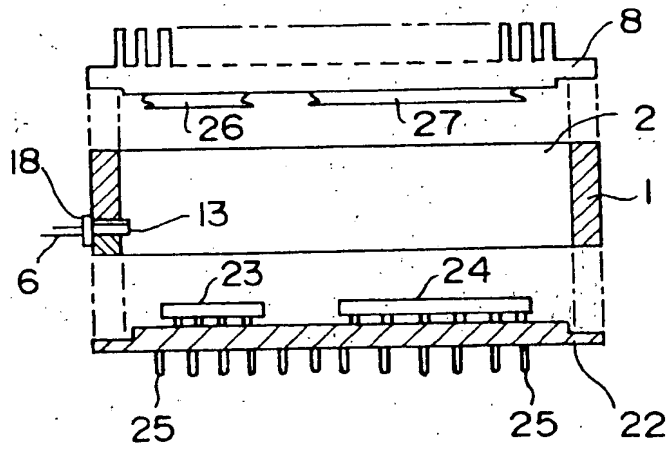


FIG. 12

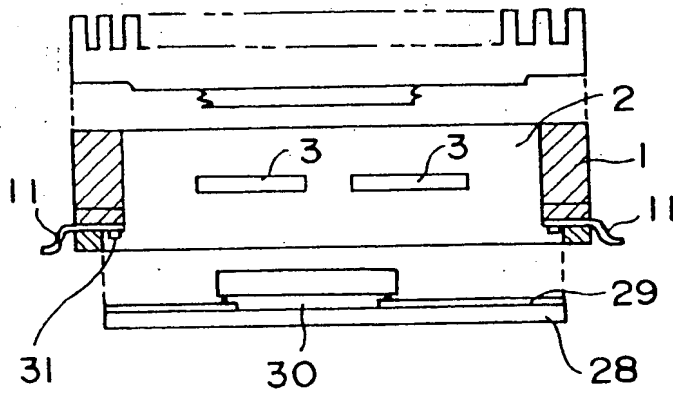


FIG. 13 (a)

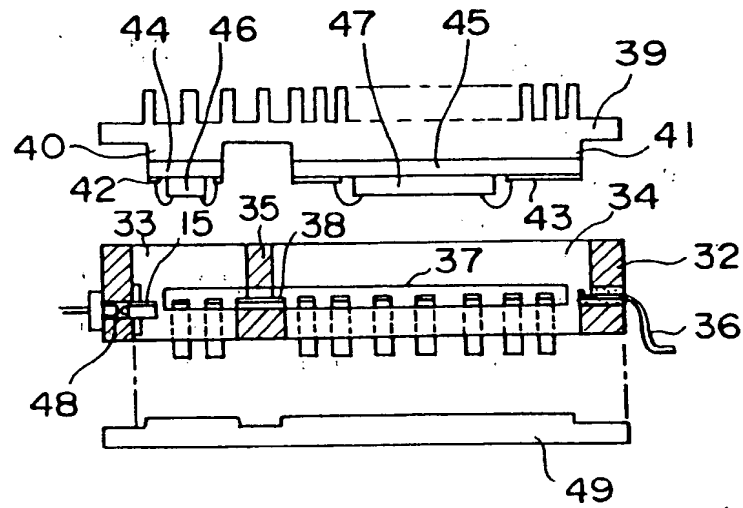


FIG. 13 (b)

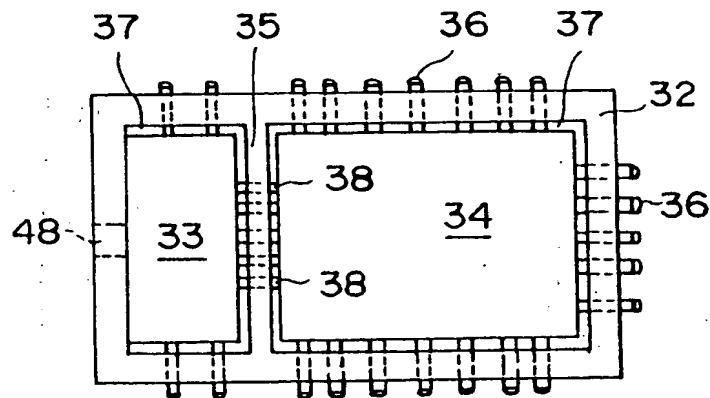


FIG. 14

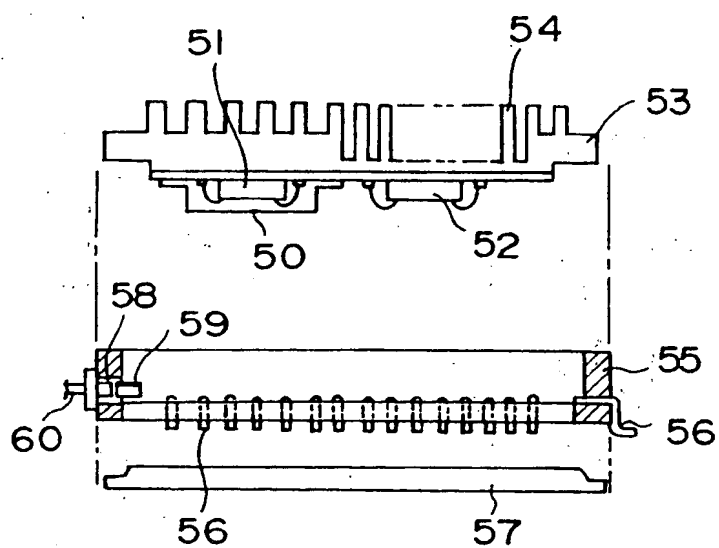


FIG. 15

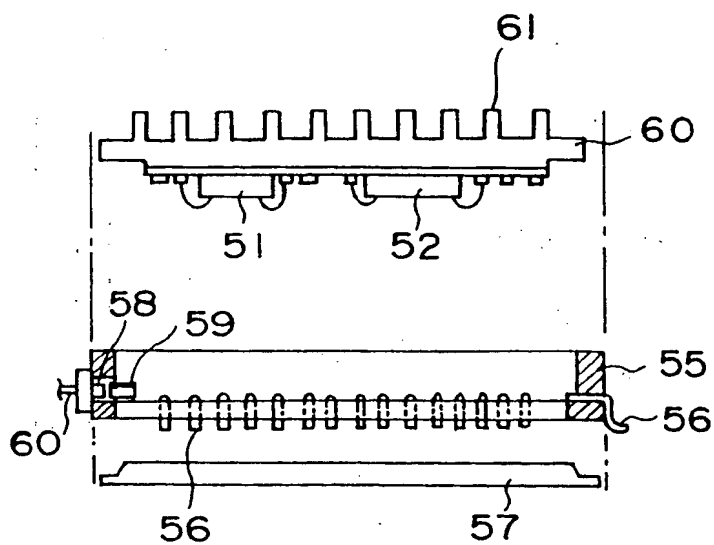


FIG. 16 (a)

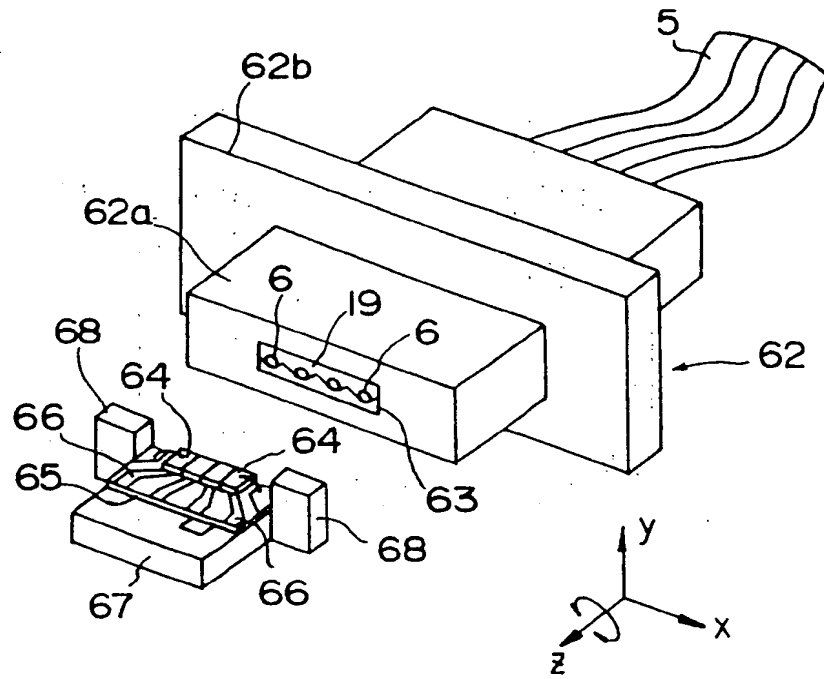


FIG. 16 (b)

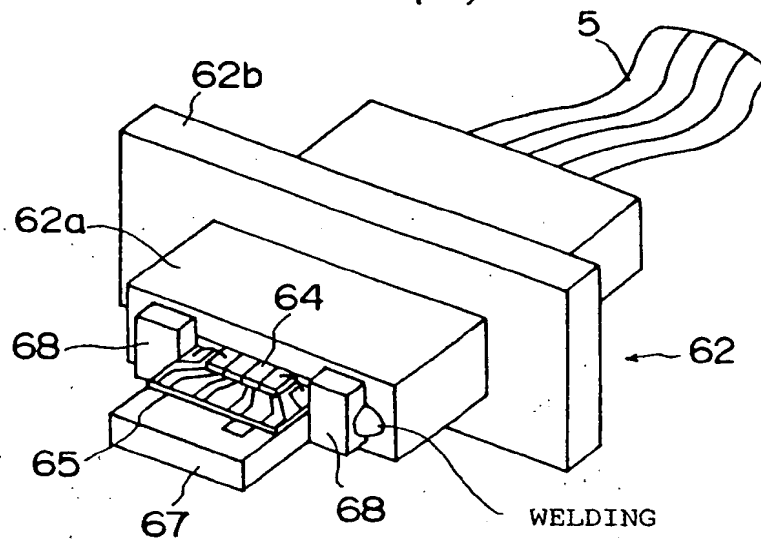
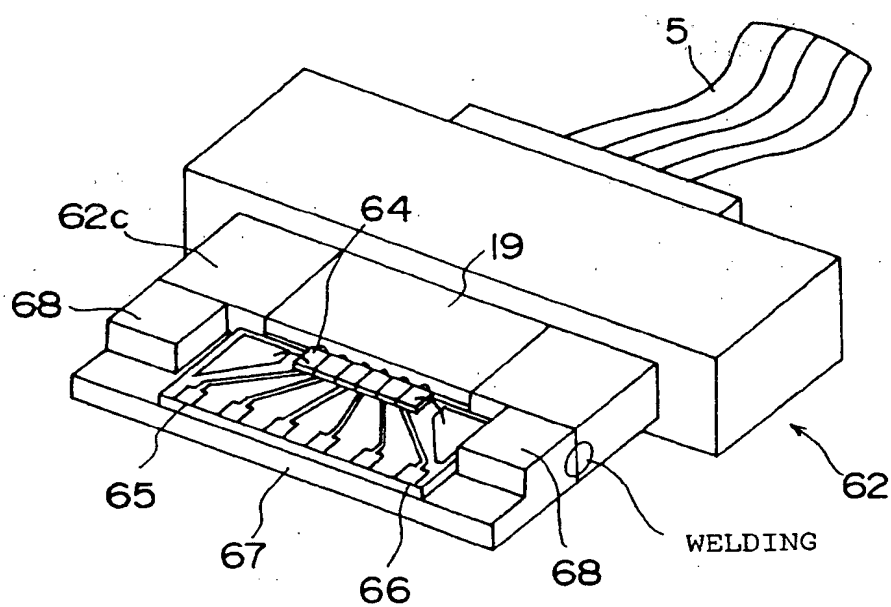


FIG. 17



(19)



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(11)

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(12)

## EUROPEAN PATENT APPLICATION

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• Nakagawa, Gohji, c/o Fujitsu Limited  
Kawasaki-shi, Kanagawa 211 (JP)

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(74) Representative:  
Fane, Christopher Robin King et al  
HASLITINE LAKE & CO.  
Hazlitt House  
28 Southampton Buildings  
Chancery Lane  
London, WC2A 1AT (GB)

(71) Applicant: FUJITSU LIMITED  
Kawasaki-shi, Kanagawa 211 (JP)

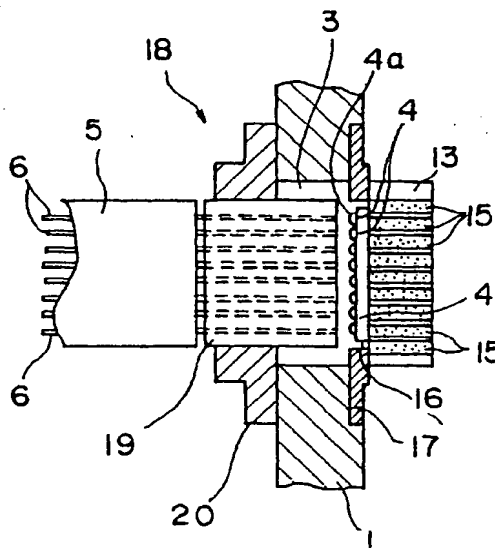
(72) Inventors:  
• Makiuchi, Masao, c/o Fujitsu Limited  
Kawasaki-shi, Kanagawa 211 (JP)

### (54) Optical fibre coupling modules

(57) A package used to couple an optical fiber (6) and an optical device (4) to each other comprises a frame member (1) open at the top and the bottom thereof for accommodating an electronic part therein, the frame member (1) having an opening (3) formed in a

portion of a side wall thereof in or adjacent which an optical fiber (6) and an optical device (4) are coupled to each other, a heat sink for closing one of the opening ends of the frame member (1), and a lid for closing the other opening end of the frame member (1).

FIG. 6 (b)



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## EUROPEAN SEARCH REPORT

Application Number  
EP 93 30 8159

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.CLS)
X	US-A-4 979 787 (LICHTENBERGER PHILIP L) 25 December 1990 * figures 1,2 * * column 3, line 23 - line 68 *	1,2,8	G02B6/42 H01S3/025 H01S3/043 H01L23/495 H01L23/498 H01L23/52
A	* idem *	24	
X	US-A-5 005 939 (ARVANITAKIS NICOLAOS C ET AL) 9 April 1991 * figures 1-4 * * column 3, line 26 - line 65 * * column 4 - column 5 * * column 6, line 1 - line 62 *	1,2,8	
A	* idem *	3,9	
X	EP-A-0 158 561 (TELECOMMUNICATIONS SA) 16 October 1985 * figures 1,2,4,13 * * page 6, line 18 - line 36 * * page 7, line 1 - line 18 * * page 12, line 19 - line 26 *	1,2	
A	* idem *	8	TECHNICAL FIELDS SEARCHED (Int.CLS) G02B H01S H01L
A	EP-A-0 213 426 (SIEMENS AG) 11 March 1987 * figure 1 * * column 2, line 24 - line 54 *	1-3,8, 17,19,20	
X	US-A-4 911 519 (BURTON WILLIAM H ET AL) 27 March 1990 * figures 1-3 * * column 3, line 20 - line 63 * * column 4 - column 5 * * column 6, line 1 - line 56 *	1,10	
A	* idem *	2,8	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14 November 1996	Examiner Mathyssek, K
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 (03.81) (P04C01)





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### CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claims:
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

### LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions.

namely:

- see sheet B -

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



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## EUROPEAN SEARCH REPORT

Application Number  
EP 93 30 8159

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 127 (E-250), 14 June 1984 & JP-A-59 039085 (FUJITSU KK); 3 March 1984; * abstract *	8,9,23	
X	WO-A-87 02833 (AMERICAN TELEPHONE & TELEGRAPH) 7 May 1987 * page 4, line 30 - line 37 * * page 6 - page 7 * * page 10, line 11 - line 36 * * figures 1,5 *	5,11,12	
E	EP-A-0 573 941 (SUMITOMO ELECTRIC INDUSTRIES) 15 December 1993 * figures 2-4 * * column 6, line 37 - line 58 * * column 7, line 1 - line 40 *	5,10-12	
X	PROCEEDINGS OF THE DIGITAL AVIONICS SYSTEMS CONFERENCE, VIRGINIA BEACH, OCT. 15 - 18, 1990, no. CONF. 9, 15 October 1990, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 297-302, XP000224575 ACARLAR M S ET AL: "A HIGH SPEED SURFACE-MOUNT OPTICAL DATA LINK FOR MILITARY APPLICATIONS" * page 298 - page 300 *	10,17	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	US-A-4 930 857 (ACARLAR MUVAFFAK S) 5 June 1990 * the whole document *	5,6,11,17	
A	EP-A-0 437 931 (AMERICAN TELEPHONE & TELEGRAPH) 24 July 1991 * the whole document *	5,7,11,13	
		-/--	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14 November 1996	Examiner Mathyssek, K
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 (01.81) (PNC01)



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EP 93 30 8159 -B-

**LACK OF UNITY OF INVENTION A POSTERIORI**

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

**1. Claims 1-4, 8-9, 14, 15, 21-24 :**

Coupling between an optical fibre and an active device in or adjacent an opening of a side wall of a housing comprising frame and lid members as well as shape of the fibre and its fixing to the housing.

The remaining claims or group of claims represent the following inventions which are not linked in such a manner as to form one single inventive concept.

**2. Claims 5-7, 11-13 :**

Way of extending the lead terminals through the frame, their attachment and methods of connecting them to electronic circuitry.

**3. Claims 10, 16 :**

Mounting method of an optical device to a fibre optic ferrule and to a support base.

**4. Claims 17-20 :**

Method of mounting and embedding electronic part within a housing and its internal construction details.



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# EUROPEAN SEARCH REPORT

Application Number  
EP 93 30 8159

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 442 608. (AMP. INC) 21 August 1991 * the whole document *	7,18	
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 254 (E-1213), 9 June 1992 & JP-A-04 054701 (FUJITSU LTD), 21 February 1992, * abstract *	16,18	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14 November 1996	Examiner Mathyssek, K
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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